

TREATMENT OF MUNICIPAL SOLID WASTE (MSW) BY THE HYDROCARB PROCESS

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INTRODUCTION

It is now generally known that the municipal solid waste problem has become an ever increasing problem in populated areas in the U.S. The increase in the standard of living manifested by a vast array of consumer goods has added to the problem of disposal of industrial and municipal solid waste (MSW). The land-fill disposal sites around metropolitan areas have become exhausted so that tipping fees are soaring. Municipalities are opting for more waste incineration or mass-burn plants. Legislation is being passed to require separation of waste for recycling and resource recovery. Because separated waste is market demand dependent, the cost of recycling is highly time and location variable. In fact, there are a number of municipalities that pay carters to remove and transport recyclable the waste to other locations which instead of becoming a source of income becomes a liability. MSW roughly consists of 50% paper and plastic and the remainder being glass, metal and kitchen waste. Industrial waste includes paper, wood and used rubber tire discard.

The most traditional waste disposal method is incineration. The modern and improved method for the same process is now termed mass-burn. In some cases, the energy generated is used to produce steam for electricity generation which can be sold, and therefore constitutes a positive value. The problem here is that the mass-burn plant generates potentially polluting gaseous and solid residue effluents. In the gaseous effluent, dioxin has been one of the most elusive and worrisome pollutants and has caused the shutting down of a number of incinerator plants. There are other gaseous pollutants, including volatile refractory organics, chlorine containing compounds, and particulates from plastic and organic waste. The chemical and biological activity in the remaining solid ash residue from incinerators is also a problem which still requires landfilling or other methods of disposal. There is concern that leachates from incinerated ash will eventually contaminate the aquifers. Municipalities are also passing legislation forbidding the use of materials which do not degrade and tend to remain in long-term storage in the landfill, such as plastics. A number of communities are outlawing disposable plastic products and appear to be returning to paper bags and containers. Much effort is also going into developing biodegradable plastics. Whether this is a sound environmental solution is yet to be determined.

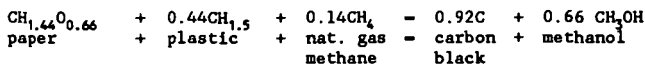
HYDROCARB WASTE PROCESS

The HYDROCARB Process offers a viable alternative. The process was originally conceived for the purpose of processing our vast resources of coal to produce a clean carbon fuel.^(1,2) However, the process can operate as well with virtually any carbonaceous raw material and certainly a large fraction of MSW qualifies as a carbonaceous material. The process is new and unique and the products formed can be used primarily as premium clean fuels as well as for the commodity market. The process depends on two basic steps, (1) the hydrogenation of coal to form a methane-rich gas while leaving the ash behind and (2) the thermal decomposition of the methane-rich gas to form carbon black and hydrogen which is recycled. The excess hydrogen and oxygen from the co-products can be a hydrogen-rich co-product which can either be hydrogen, methane, methanol or water. Figure 1 shows a

schematic flow with alternative feedstocks, coal, wood or MSW and with co-feedstock additions.

Figure 1 gives a schematic of the process listing various feedstock materials, additives and co-products. The process can be made very efficient because the only raw material used is the carbonaceous material. The energy required to operate the process is relatively small. The overall reaction is thermally neutral. The primary product is always carbon black which can be used as a clean burning fuel and can also supply the market for vulcanization of rubber for automotive tires, pigment for inks and paints and for lubricants. The co-product hydrogen-rich gas can primarily be used as a burner fuel and the methanol as an automotive fuel, or as a commodity chemical, or can even be converted to gasoline. The process is fundamentally different than mass-burn in that it operates in a reducing atmosphere rather than in an oxidizing atmosphere and it is run in a closed system under pressure. Temperature conditions are about the same or perhaps even somewhat lower than in mass-burn incinerator plants. Because of the elevated operating pressure and reducing atmosphere, no dioxin can be formed and all the oxygen containing organic material is reduced to carbon and methane and any metals that may be present in the waste are kept in their reduced state as opposed to mass-burn where the metals can become oxidized. The following describes how the process can be effectively used in processing MSW and the economic dynamics of the process.

The process can be used with either separated or non-separated waste. To simplify the example and avoid discussion of head-end costs, we will give examples of the process operating on separated waste. Thus, the main MSW feedstock is paper and plastic and we can include rubber tires for this example. Since paper is essentially produced from wood, the process can be represented by the following chemical stoichiometric formula, limiting the products to carbon and methanol.



Notice that the formula for plastic contains only C and H, like rubber and methane. The oxygen containing material in paper is in the form of hemi-cellulose. The above equation is based on an assumed MSW composition such that the amount of plastic is 25% of the weight of paper. This can be changed for specific sites and the mass balance adjustment can be made by varying the amount of natural gas added. The gas can be purchased from the local gas company in the particular area where the waste is being processed. We now have to set the production capacity of the plant. Mass-burn incinerator plants have been built in the 2,000-3,000 T/D capacities in and around metropolitan areas. Of course, around New York, for example, it might be worthwhile building a 10,000 T/D or more of waste paper and plastic HYDROCARB plant. However, for this and generally more widespread applications, we will fix on a 3,000 T/D MSW processing capacity which would contain 2,400 T/D paper and 600 T/D plastic.

We now calculate that to run this plant, we have to add 226 T/D of natural gas from the natural gas pipeline company's distributing company. This natural gas is equivalent to 10.7 million SCF/D of methane, which must be purchased from the gas company. The separated MSW is thus co-processed with natural gas.

ECONOMICS

We now must estimate the capital investment of the plant. We can obtain this estimate by scaling down from a large plant we estimated in detail, operating on 25,000 T/D of coal. Because this is a volumetrically controlled process, we can scale it by the well known 0.6 power factor of capacity. The 25,000 T/D plant

making carbon and methanol from coal is estimated to cost $\$800 \times 10^6$. Thus, the 3,000 T/D waste plant will cost:

$$800 \times 10^6 \times \left(\frac{3000}{25000} \right)^{0.6} = \$200 \times 10^6$$

We can now calculate a selling price for the carbon black fuel and methanol co-product. The financial parameters operating on the capital investment are as follows: capitalization 80% debt/20% equity, 20 yr depreciation, 11% interest on debt, 25% return on equity (ROE) and 38% tax on ROE before taxes. This results in a 21.9% annual fixed charge operating on the total capital investment.

We assume a high natural gas cost from the gas company of $\$5.00/\text{MSCF}$ which equals a cost of $\$0.119/\text{lb CH}_4$. We then add operation and maintenance cost and the 21.9% fixed charges on the $\$200$ million capital investment. We can now calculate the G price of the MSW value of the waste taken from the municipality, which can range from a negative value, in which case the community pays the processor to take the waste away, to a positive value in which case the processor pays the community to acquire the waste for processing. We shall first calculate a breakeven G price for the waste in $\$/\text{Ton}$ in Table 1, assuming we obtain $\$5.00/\text{MMBtu}$ for the resulting fuel products.

TABLE 1
HYDROCARB WASTE PROCESSING PLANT
Plant Factor 90%, Efficiency 90%, capacity 3,000 T/D
Production Capacity of Fuel - 11,000 Bbl/D Fuel Oil Equivalent

Production Cost		\$/Day	
Waste Cost	-	3,000 T/D x \$G/Ton	
Nat. Gas	- $0.119 \times 226 \times 2,000$	-	53,000
Op & Maint	- $\frac{3,000}{25,000} \times 120,000$	-	20,000
Fixed Charges	- $\frac{0.219 \times \$200 \times 10^6}{328}$	-	133,000
			<u>206,000 + 3,000 G</u>

Thus,
 $206,000 + 3,000 G = 0.9 \times (3000 + 226 \text{ T/D}) \times \frac{22.9 \text{ MMBtu}}{\text{Ton}} \times \frac{\$5.00}{\text{MMTU}}$

Solving for $G = \$41.50/\text{Ton}$; this is what the processor can afford to pay the town for taking the MSW for processing and while still obtaining a 25% return on equity.

The above is based on a fuel value for a C-methanol composition makeup mixture of 34.3% carbon in 65.7% methanol by weight. The plant produces 700,000 gal/Day of this C-methanol slurry which is equivalent to 11,000 Bbl/D of fuel oil equivalent.

If we assume the processor obtains the waste from the town free, so that $G = \$0/\text{Ton}$, we can then calculate the selling price of $\$3.10/\text{MMBtu}$ for both co-products carbon and methanol. This is equivalent to $\$18.70/\text{Bbl}$ oil or $\$0.44/\text{gal}$.

Now if the town pays the processor $\$25/\text{Ton}$ to cart the waste away (as some towns on Long Island have already done), then the selling price for carbon and

methanol can come down to only \$2.00/MMBtu which is equivalent to \$12.00/Bbl fuel oil equivalent or \$0.28/gal while maintaining a reasonable return on the investment equity.

At \$2.50/MMBtu which is highly competitive with oil at \$15.00/Bbl, the town would only have to pay \$13.50/Ton to a processor to take it away.

The conclusion is that even at a waste capacity of 3,000 T/D and an investment of \$200 x 10⁶, the processor can sell the carbon and methanol as a clean burner fuel for domestic and industrial boilers, as well as for diesel and turbine engines at an economically attractive price. Additional return can be obtained by the processor selling the methanol and carbon at a higher price to the chemical commodity market so that the cost of waste disposal would even bring a profit to the town by selling the waste to the processor at a higher price.

The above indicates that the HYDROCARB Process for the disposal of MSW is highly attractive and should be taken up for development on a fast track schedule. Because this process utilizes natural gas for co-processing waste in a reducing atmosphere, not only is the process environmentally acceptable but is potentially economically attractive and thus it should be worthwhile to develop this process in conjunction with a municipality that is generating the waste.

REFERENCES

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